SPACE SHUTTLE PROGRAM

Process Control Focus Group

2004 ANNUAL REPORT

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Process Control Focus Group 2004 Annual Report

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PROCESS CONTROL

Gets us there!

Executive Summary

During the past year, everyone involved in the Space Shuttle Program (SSP) has been focusing on returning to flight safely and implementing the recommendations from the Columbia Accident Investigation Report. A major area of emphasis is the redesign effort of the External Tank to preclude large pieces of foam from shedding off and becoming debris capable of damaging the Orbiter. There have also been numerous modifications to improve existing hardware and additional capabilities added to increase the safety of the crew and vehicle.

The date for the first launch slipped to the May/June 2005 timeframe due to weeks of unanticipated lost work time at Kennedy Space Center resulting from hurricanes Charley, Frances, and Jeanne. Several facilities experienced extensive damage including the Vehicle Assembly Building where the Orbiter is mated to the External Tank and Solid Rocket Boosters. The SSP is diligently working toward completing all of the required design and certification reviews to ensure a safe return to flight with the Orbiter Discovery on STS-114.

The Process Control Focus Group (PCFG) has continued to produce process control awareness products and released "Countdown 4: Return to Flight," which highlights the redesign efforts involving the External Tank. The short inspirational video, "Process Control Gets Us There" focuses on the role of process control on a successful human space program from the Mercury Program in 1961 to the exploration of Mars and beyond. A poster was developed depicting the vehicles of the past and into the future emphasizing "Process Control Gets Us There."

An interactive CDROM was developed that features the two short videos, "To Fly" and "Process Control Gets Us There" to enable a larger viewing audience by utilizing an individual's computer. An exploration simulation game that tests your ability to maneuver a space vehicle is included as well as a screen saver that is a compilation of launch photos and mission highlights from Mercury, Gemini, Apollo, Shuttle, and the International Space Station.

These products are professionally produced and the videos have received numerous Telly Awards over the past few years in the categories of Safety, Employee Communication, and Internal Communications/Corporate News Magazine. The Telly Awards, founded in 1978, are considered the premier award honoring outstanding video and film productions. All of the products developed by the Process Control Focus Group are available at no cost by completing the order form at www.CountdownOnline.tv or by contacting a PCFG representative listed in Appendix A.

The success of the human space program depends on all of us to ensure requirements are met, process changes are coordinated and communicated, and the culture encourages employees to call a "time-out" when something doesn't look right. The PCFG will continue to produce products and tools to assist management in communicating the importance of process control and share best practices and lessons learned across the Space Shuttle Program.

Awareness Campaign

The Process Control Focus Group (PCFG) strives to develop entertaining products to reach the workforce, while delivering the message of paying attention to detail and providing examples where something seemingly insignificant caused an escape to occur. The Space Shuttle Program (SSP) has requirements in place that may on the surface appear to be too stringent, however it is a complex system and the effects of a change to a process may negatively impact subsequent processes thereby increasing the level of risk.

There are various categories of risk. The known risks are mitigated by redundant systems and safeguards, the unknown risks are when a change is made to a product/ process, but is not communicated properly and the consequence is unknown, and then the unknown unknowns or in other words, we don't know what we don't know. Risk is inherent to the SSP, however if everyone in the supply chain understands the importance of process control and performing to established requirements, some level of the risk is alleviated.

The mission of the Process Control Focus Group is to reduce risk to the Space Shuttle Program by reducing and/or eliminating process escapes.

The PCFG continues to address culture and human behavior through the production of the awareness products and recognizing individuals who take the initiative to prevent an escape from occurring. Every individual on the SSP must be personally accountable for the work that he or she performs and understand the potential impact if the requirements are not met. A goal of the PCFG is to shares this message during supplier visits, conferences, and through partnering with other organizations.

Awareness Products

Each year the PCFG brainstorms the concepts for the products to be developed the coming year and what the main message will be. Since the shuttle fleet was grounded during 2004, the focus across the Program has been on return to flight, the redesign efforts and completing the recommendations from the Columbia Accident Investigation Board Report. The PCFG felt the Space Shuttle Program workforce would find value in a video that explained the events that led up to the tragic loss of Columbia and her crew on February 1, 2003 and present the challenges of redesigning the external tank.

As a result of those discussions, the latest in a series of videos is "Countdown 4: Return to Flight." This episode uses state of the art animation to illustrate why the foam from the bi-pod area of the external tank shed away. While this was not a new phenomenon it was the first incident to cause damage severe enough to allow hot gases to permeate the wing during re-entry causing the break-up of the vehicle and loss of crew. The challenges facing the engineers to redesign the tank in an effort to eliminate or minimize the foam loss from the external tank is also presented in this episode of Countdown.

The Human Space Flight Program has been successful since the Mercury program in May 1961 and process control was a vital element of that success. To communicate that message, "Process Control Gets Us There" was produced featuring NASA's Space Shuttle Program Manager, Bill Parsons and astronauts Pam Melroy and Andy Thomas. Process Control will ensure a safe Return to Flight, completion of the International Space Station, return to the Moon, on to Mars and beyond. To compliment the video a poster containing the vehicles of the past and into the future was developed as a daily reminder that "Process Control Gets Us There."

A portion of each series of Countdown is dedicated to a segment entitled Celebrity Watch where an individual or group is recognized for discovering a process escape and intervening or

Pete Hopman and Ryan Loporto with Julia Park.

preventing an escape from occurring. In this latest episode, Pete Hopman and Ryan Loporto from Kennedy Space Center, Florida were recognized for creating a custom database, which was used to maintain process control during the recovery, analysis, and investigation of the Space Shuttle Columbia debris. Pete and Ryan exemplify the dedication and commitment of the Space Shuttle Program workforce to recover from the Columbia tragedy and return to flight safely. If you or someone you know has prevented an escape or intervened before additional damage could be done, go to www.CountdownOnline.tv and complete the Celebrity Watch nomination form.

For those individuals that are not selected for the Celebrity Watch segment of the videos they are eligible for the Space Shuttle Program Process Control Champion Award. This award is another opportunity to recognize and promote awareness of process control and is given to those individuals who report a concern and/or prevent an escape.

Two such awards were presented this year. Mr. Augustin Ruelas of LeFiell Manufacturing Company was recognized for his efforts to reduce process creep during the production of the Space Shuttle Main Engine Nozzle Coolant Tubes. Mr. Ruelas suggested that LeLiell and Boeing Rocketdyne form a team to evaluate the high-pressure dies that are utilized to form the coolant tubes prior to stacking and brazing. The dies have been in use for over 20 years and as the die cavities have worn over the years, they can create an undesired effect on the process. The identified effect is when the tubes are tapered to the blueprint specified outside diameters and wall thicknesses then high pressure formed in worn or oversize die cavities, the tubes are subjected to increased or unplanned expansion rates. Unplanned expansion could result in a dangerous wall thinning condition on the coolant tubes. The joint team was able to determine the planned and unplanned expansion rates and made changes to the blueprint to return the dimensions to allow a predictable and safe expansion rate.

Augustin Ruelas, LeFiell Mfg. Co.

John Lively, Dr. Jan Davis, and Fred Whitman

The other award recipient was Mr. John Lively of Pratt & Whitney in West Palm Beach, Florida. Mr. Lively demonstrated a commitment to process control and safety of flight when he recognized a potential problem with the fluorescent penetrant inspection process. He is responsible for conducting Probability of Detection (POD) demonstrations for periodic recertification of inspectors. During a scheduled POD demonstration using a Liquid Oxygen (LOX) compatible penetrant, the inspector being examined was producing unsatisfactory results. Although some of the problem was attributed to a faulty borescope, Mr. Lively suspected that thee might be an issue with the penetrant. While penetrant testing has not been required in this application, he insisted that the penetrant be examined. Subsequent investigation determined that the penetrant's brightness had degraded as compared to a control sample. Corrective and preventive action included replacing the existing supply of penetrant, and establishing a shelf-life and/or periodic testing for this class of penetrant.

Neither the aerospace industry nor the penetrant manufacturer recognized that some penetrants would degrade over time. Mr. Lively's attention to detail, focus on quality and drive to look beyond current process acceptability precluded the possibility of substandard inspections and deterred a potential risk to flight safety.

It is individuals like this that deserve to be recognized for their actions of going above and beyond their specific job duties. Contact any of the PCFG representatives if you would like someone to be considered for a Space Shuttle Program Process Control Champion Award.

The use of multimedia has been the methodology of the PCFG to ensure that everyone across the Space Shuttle Program receives the message of process control. An interactive CDROM following

the theme is comprised of the two short videos, "To Fly" and "Process Control Gets Us There," a simulation game, screen saver, and process control resources. This CD and the above mentioned products are designed to appeal to everyone in some way and inspire them to do their part in ensuring a safe and successful human space program far into the future.

Communication

There are various forums that the PCFG takes advantage of to provide the products identified above and to share lessons learned and best practices. The prime contractors conduct supplier visits and meet with the executive management team and request the participation of the employees working on the Shuttle Program. This type of environment affords the opportunity for questions and discussing any issues or concerns. The videos are an excellent tool to express the importance of process control and what effects subtle changes can have on the overall product.

Astronaut Doug Wheelock talks with employees of Allied Resources in Fairfield, New Jersey

The prime contractors also work through the Astronaut Office and request an astronaut participate in a supplier visit. Many suppliers have never seen a launch or even understand how their product fits into the overall Shuttle system so when an astronaut speaks it is extremely powerful. The astronauts who have supported the PCFG on supplier visits have been exceptional and have interacted directly with the workforce signing autographs and answering questions.

The PCFG or representatives from it have participated in various conferences over the past few years such as, the Space Shuttle Program Supplier Symposium, Conference on Quality in the Space and Defense Industry, and for the first time this past year the Foreign Object Debris 25th Annual Conference in Atlanta, Georgia. As part of that conference, the PCFG conducted an educational workshop on process control. In addition, the PCFG operated a booth and provided free copies of all of the products and answered questions from the attendees. The feedback we received from our participation was great.

PCFG Members: Jim Shearer, Todd Sims, Terry Keeney, Jon Cowart, Tammi Belt, Mike Gemme, Fred Whitman, and Lionel Ribeiro at the Foreign Object Debris (FOD) 25th Annual Conference.

In addition to one on one contact and sharing of information, the PCFG maintains two separate websites. The www.CountdownOnline.tv site is available to order any of the free products or nominate someone for Celebrity Watch.

The www.process.nasa.gov site contains the Annual Reports, PCFG Contact List, Standards & Practices Document, and a Tool-Box of items to assist the supplier in enhancing their systems.

Contractor Initiatives

ATK Thiokol

Supplier Viability Project

The Reusable Solid Rocket Motor (RSRM) is built at ATK Thiokol – Promontory, but it is highly dependent upon outside suppliers who provide 40-50% of the motor in materials, parts, and assemblies. Approximately 120 end-item suppliers provide >500 end-items and hundreds of additional suppliers provide support materials.

Suppliers face increasing threats to their businesses including low or reduced production rates and general market problems and weaknesses. In addition to the overall viability of their businesses, they encounter challenges that potentially affect their ability to provide consistent material to support RSRM production.

- Experienced workers retire depleting the corporate knowledge
- Unplanned material and process changes threaten hardware reliability
- Sub-tier material changes affect their products
- Obsolescence adds qualification costs and manufacturing flow

ATK Thiokol has gone beyond the traditional management methods to partner with suppliers. The ***Supplier Viability Project*** is structured to dramatically increase face time with suppliers to provide better visibility of potential issues and to incorporate stronger process control at suppliers.

Step 1: Focus Internal Resources

The ATK Thiokol personnel supporting a supplier (buyer, program manager, procurement quality engineer, design engineer, etc.) are more effective and efficient as a group (synergy) than if working apart from (or especially against) other members of the team. To capture the potential synergy, teams are co-located and meet together to share information and jointly develop their strategies.

Step 2: Utilize A Supplier-Friendly Culture

An open and honest partnering relationship is good for both ATK Thiokol and its' suppliers. Suppliers typically bring significant experience and technical expertise in their respective systems. The RSRM Program benefits by recognizing the strengths of these personnel.

Approaching supplier relationships with humility and encouraging non-punitive collaboration helps to resolve issues positively. Understanding a supplier's needs, working together to eliminate non-value added steps, reducing cycle time for administrative processes, and simplifying requirements all support this partnership.

Step 3: Face Time With Suppliers

Key to effective partnership is trust and understanding. The RSRM Supplier Viability Project expands the team's role to enhance relationships with suppliers and fortify their viability as a business and as a provider of consistently good material to support the RSRM. Teams develop and implement strategies to keep suppliers healthy with more robust processes.

Teams assess the companies who support their component and develop a strategy to support the supplier's viability and

processes. They consider the challenges and issues as well as opportunities.

One effective vehicle for enhancing the partnership has been Focus Group Meetings. ATK coordinates with a key supplier(s) to invite representatives from second and third tier suppliers to a hosted mini-symposium. Ideally, the ultimate customer – an astronaut – keynotes the kick-off. Program expectations and process control tools are discussed. Given this broader appreciation of expectations, one third tier supplier notified ATK Thiokol of a future material change driven by obsolescence. The supplier and ATK Thiokol worked together to understand potential effects and qualify the pending change.

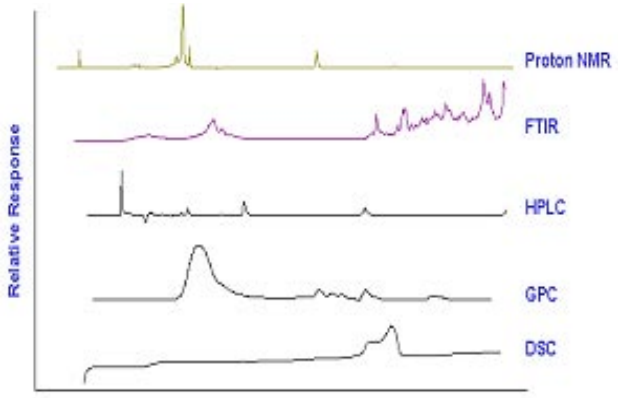
An RSRM-supplier symposium was held in June 2004 in conjunction with the FSM-11 static firing. Approximately 120 supplier representatives from 61 RSRM suppliers attended. The program focused on Space Shuttle return to flight and future space program opportunities. A motivational message from retired Major General Perry Smith highlighted the meetings.

Teams take the lead to identify the need and plan for visits, symposiums, audits, awards, process control tools, etc. Suppliers may benefit from tools developed by ATK Thiokol and the Shuttle community such as Process/Product Integrity Audits (PPIA), Process Failure Modes and Effects Analysis (PFMEA), personal warranty, etc.

Step 4: Fingerprinting Of Raw Materials

Chemical fingerprinting uses state-of-the-art analysis techniques to determine changes in material processes and ingredients. Each lot of material is chemically analyzed to establish a chemical fingerprint. This fingerprint is then stored in a database for use in accepting future lots of material. When a new lot of material arrives, it is tested and characterized to monitor supplier process drift and raw ingredient changes.

Besides using this effectively for raw materials, the RSRM program is providing the system and protocols that make it operate effectively to select RSRM suppliers who will fingerprint their raw materials to detect sub-tier supplier changes.



Lockheed Martin Space Systems Company, Michoud Operations (LMSSC, MO)

Launched the *Foreign Object Damage (FOD) Prevention Program*

FOD is a substance, debris or article alien to the vehicle or assembly that would potentially cause damage. FOD can be any misplaced consumable, hardware, or tool. Also, any damage caused by a foreign object that can be expressed in physical or economic terms.

What is the Foreign Object Elimination (FOE) Program?

The FOE program is a formal, documented and disciplined program designed to prevent the introduction of foreign objects into all deliverable and non-deliverable hardware.

The purpose of the FOD initiative is to insure that deliverable products are free of any foreign materials. Eight prime suppliers manufacture FOD critical hardware for the External Tank Program. The following requirements were contractually imposed:

"Each contractor shall maintain a FOD control program assuring work is accomplished in a manner preventing foreign objects or materials from entering and remaining in deliverable items. Maintenance of the work area and control of tools, parts and material shall preclude the risk of FOD incidents. The contractor shall document and investigate all FOD incidents assuring elimination of the root cause. Lockheed Martin shall have the right to perform inspections, verification and FOD Prevention Program audits at contractor's facility to assure program documentation and effective-ness. The contractor shall identify a FOD control person responsible for implementing FOD prevention, awareness and training. Prior to closing inaccessible or obscured areas and compartments during assembly, the contractor shall inspect for foreign objects/materials. Tooling, jigs, fixtures, and test or handling equipment shall be maintained in a state of cleanliness and repair to prevent foreign object damage (FOD). Contractor shall provide a statement of certification that deliverable products are free of any foreign materials that could result in foreign object damage to the installed product or companion components/systems."

Basic FOD Program Requirements:

There are several basic elements that make up the FOD program requirements. Each prime supplier is required to write FOD procedures incorporating these elements:

- Training
- Early Design Considerations
- Assembly Sequencing
- Handling of Material
- Housekeeping
- Awareness
- Control of Tools and Personal Items
- Hardware Control
- Metrics
- FOD Incident Reportage
- Incident Analysis
- Hazardous Material
- Access Controls

Preventive Practices:

The following practices are to be incorporated into the suppliers FOD program and procedures. These are to be incorporated into the suppliers build

documentation and flowed down to the sub tiers as needed.

- Follow Procedures
- Practice Good Housekeeping, "Clean-As-You-Go"
- Account for Tools & Hardware at Specific Intervals
- Develop Procedures for Inspecting Inaccessible Areas
- Awareness Training
- Provide Storage Areas for Ladders, Hoses, Tool Boxes & Other Work Aids
- Brief Lessons Learned
- New Employees must Complete FOD Training Before Beginning Work in FO Sensitive Areas

FOD Survey Questionnaire:

The Lockheed Martin Michoud Operation Procurement Quality Assurance Field Engineer assigned to the prime supplier will review the suppliers FOD program using the following questions:

√ Does the supplier have a documented FOD Program and FOD Control Plan?

√ Does the FOD Control Plan clearly address control of work areas, tools, parts, and materials?

√ Does the supplier's plan define how foreign object incidents will be reported, investigated, and eliminated by root cause corrective action?

√ Does the supplier's plan identify a person or management position(s) responsible for the implementing of the FOD Program?

√ Does the supplier's plan address and assign prevention, personnel awareness and training?

√ Does the supplier's plan require controls for assuring cleanliness of test systems, tooling, jigs, fixtures, and handling and packaging equipment?

√ Is there evidence of compliance to the FOD Program in the manufacturing and test areas?

√ Do they flow-down FOD Program requirements to their suppliers?

√ Is the supplier prepared to provide the required FOD compliance certification with hardware shipment?

Forward Planning

The Space Shuttle Program and the American public is eagerly awaiting the first return to flight mission during the May/ June 2005 timeframe. The International Space Station needs to be completed and the astronauts living in space are depending on the Shuttle Program to bring supplies and much needed equipment. Upon completion of the Station, the next step is back to the Moon and then on to Mars and beyond.

The PCFG is already brainstorming products for the coming year, which will include a documentary on the Columbia. It will contain the history of the Columbia, recovery efforts, investigation and return to flight. This documentary will be produced in high definition in anticipation of national distribution for viewing on cable television. The goal of this documentary is to bring forth a full understanding of the Columbia accident and the return to flight effort while focusing attention on the future of human space travel.

Remember……..Process Control Gets Us There!

Appendix A

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